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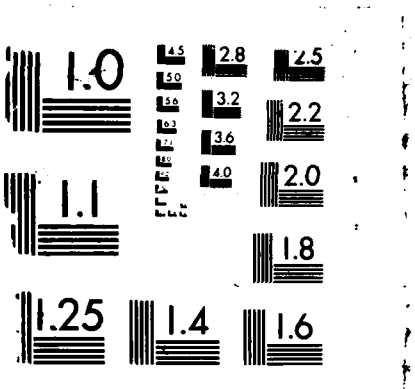

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The research supported under this grant has led to new developments for solving nonlinear optimization problems involving functions that are not everywhere differentiable and/or are implicitly defined, such as those that arise from dual formulations of optimization models.

A new result has been proved showing rapid convergence of an algorithm

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for the single variable case where generalized derivations are available. For the single variable case where only function values are used a safeguarded bracketing technique has been introduced which guarantees convergence for lower semicontinuous functions and preserves rapid convergence of polyhedral and/or polynomial fitting algorithms. A safeguarded polyhedral/quadratic fitting algorithm has been developed which has better than linear convergence for certain piecewise twice continuously differentiable functions.

Ideas from the single variable case are being extended to the multi-variable case.

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The research conducted under Grant Number AFOSR-83-0210 during the period 15 July 1985 to 14 July 1986 is partially reported on in [1], [5], [6], and [7].

The goal of this project is to develop methods to solve efficiently constrained minimization problems that have problem functions that are not everywhere differentiable. Such difficult problems occur in practice when decomposition, nested dissection, relaxation, duality and/or exact L_1 penalty techniques are applied to large or complicated nonlinear programming problems in order to convert them to a sequence of smaller or less complex problems. Being able to use these techniques that often give implicitly defined problem functions gives a user flexibility in modeling a problem for solution and the ability to exploit parallel processing in computation.

For the case of minimization of a function of a single variable where generalized derivatives are know a new rapid convergence result has been proved in [5] for the algorithm developed under this grant in [2] and [4]. This algorithm maintains two points that define a bracket containing the problem solution. Via quadratic and polyhedral approximation each iteration determines a new point that becomes a new bracket endpoint and, hence, defines a new bracket. The result of [5] is that either the new point is superlinearly closer to the solution than both current bracket endpoints or the length of the new bracket is superlinearly shorter than that of the current bracket. This is proved under very weak convergence rate assumptions. This result was reported at and will appear in the proceedings of the International Conference on Numerical Optimization and Applications held at Beijing, China in June 1986.

In a private communication K. G. Murty has informed the principal investigator that the above algorithm will be described in a new book he

is writing. Also, he has reported very successful use of PQ1, the corresponding FORTRAN subroutine [4], by colleagues at the University of Michigan.

Together with J.-J. Strodiot the principal investigator has written two papers [6] and [7] to be submitted for publication on algorithms for single variable minimization which use only function (i.e. not derivative) values. In [7] a very general safeguarded bracketing technique is introduced which guarantees that the algorithm iterates are sufficiently distinct and that the iterate sequence converges to a stationary point as defined by Rockafeller [8] for lower semicontinous functions. When this technique is combined with certain sequential polynomial and/or polyhedral fitting methods it preserves certain types of rapid convergence. Each bracket has an interior point whose function value does not exceed those of the two bracket endpoints. The safeguarding technique consists of replacing the fitting algorithm's iterate candidate by a close point whose distance from the three bracket points exceeds a positive multiple of the square of the bracket length. Also, in [7] it is shown that a given safeguarded quadratic fitting algorithm converges in certain better than linear manner with respect to the bracket endpoints for a strongly convex twice continously differentiable function.

In [6] an algorithm for nonsmooth problems is introduced which uses function values at five points to generate each iterate. It employs polyhedral approximations as well as quadratic approximations and the above safeguard. The method has the type of better than linear convergence defined in [3] for certain piecewise twice continously differentiable functions. These results were presented at the TIMS/ORSA Joint National Meeting at Los Angeles in April 1986.

Current research is concerned with developing an efficient numerical method for n-variable minimization based upon the ideas in [3] and the thesis [1] of the principal investigator's former Ph.D. student N. Gupta.

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